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Effect of Seizures on Heart: Statistical Study of EEG-ECG Signals

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ABSTRACT:
The present work is an attempt to analyze the interdependence of brain-heart electrical activities. Seizures are disordered brain activity which may or may not be epileptic. This disturbed brain signal may affect the heart electrical activity. We have measured the central tendency and covariance of electroencephalogram (EEG) and electrocardiogram (ECG) signals. Our result is in accordance to the previous studies on brain-heart interaction.

Key words: EEG, ECG, Power spectrum, Covariance, Seizures, Autonomic Nervous System

INTRODUCTION

The heart is the hub of circulatory system whereas brain is the hub of the nervous system. According to many studies it has been proved that the autonomicnervous system controls the heart rate [1]. Heart also neurologically, biochemically, biophysically and energetically affects the brain [2,3]. So, we can say that heart and brain interact with each other in a way that heart can affect brain and vice-versa. Epilepsy is a brain disorder in which a person has repeated seizures (convulsions) over time. Seizures are episodes of disturbed brain activity that cause changes in attention or behavior (http://www.ncbi.nlm.nih.gov/ pubmedhealth / PMH0001714/).

As proposed by the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE) in 2005, epilepsy is defined as abrain disorder characterized by an enduring predisposition to generate epileptic seizures and by the neurobiological, cognitive, psychological, and social consequences of this condition [4]. In 1929, Berger discovered that electrical brain signals could be recorded from the human head by using scalpelectrodes; this discovery led to the use of electroencephalography (EEG) to study and classify epilepticseizures(http://emedicine . medscape . com / article/1184846-overview) [5]. Heart electrical activity is measured by attaching electrodes to the outer surface of skin of the body. This noninvasive recording is called electrocardiogram (ECG or EKG).Epilepsy and seizures can affect the autonomic nervous system ultimately producing heart rhythm disorder [6, 7].

MATERIALS AND METHODS

We have taken the data from CHB-MIT Scalp EEG Database of Neuroelectric and Myoelectric Databases of the PhysioBank archives of the PhysioNet web site (http://www.physionet.org/). The PhysioNet web site is a public service of the PhysioNet Resource funded by the National Institutes of Health's NIBIB and NIGMS. About 45,000 visitors use PhysioNet each month, and the main PhysioNet server at MIT supplies about 4 terabytes of data (about 8 million hits) each month [8, 9]. This database contains EEG recordings of 22 pediatric subjects with intractable seizures, monitored for up to several days following withdrawal of anti-seizure medication to characterize their seizures and assesstheir candidacy for surgical intervention [10]. In all, the onsets and ends of 182 seizures are annotated. We have concentrated on case chb04 who is a male of 22 years. We have taken 8th and 28th annotating filesout of all three files which contains one or more seizures. These three files are chb04/chb04_05.edf, chb04/chb04_08.edf and, chb04/chb04_28.edf. Case chb04 have 36 files also with ECG recording. Two files, chb04/chb04_08.edf and chb04/chb04_28.edf, are among that files which have ECG recording along with EEG recordings.

Fig.1 and Fig.2are showing waveform of EEG(FP1-F7 signal) and ECG of chb04_08 normal and seizures duration. For our work, we have taken these two files. The details are given in Table 1. All computational work have been done by using Matlab numerical computing environment software (http://www.mathworks.in/).To execute the statistical study of the interdependence of ECG and EEG signals, we have calculated mean and covariance of these signals for normal condition as well as seizures duration.

RESULTS

Table 2 represents all calculated relative values of central tendency (mean and variance) and covariancevalues of EEG and ECG signals for non-seizures andseizures duration for both files. Mean EEG values of chb04_08 and chb04_28 files are near zero for normal recording time but values are increasing for seizures time. Mean values of ECG of the files arenot giving any significant pattern to discriminate the normal and seizures duration. EEG variance is also increasing for seizures duration but ECG variance isnot showing any clue of effect of seizures.But the value of EEG-ECG covariance is increasing with the onset of

seizures.Fig.3 and Fig.4 are showing power spectra of EEG (FP1-F7 signal) and ECG of normal and seizures duration of chb04_08 file respectively, whereas Fig.5 and Fig.6 are showing power spectra of EEG (FP1-F7 signal) and ECG of normal and seizures duration of chb04_28 file respectively. The details of findings are tabulated in Table3. The maximum power is always shifting to the lower period signal for both type of signals (EEG, ECG) and this pattern is same for both files i.e. chb04_08 and chb04_28.

CONCLUSION

The brain disorder of subject is generating disordered neuron currents which should produce changed stimulus to the heart electrical system. This phenomenon is being reflected in our analysis, because if that were not the case then value of covariance should have decreased for the transient phase of seizures. But the value is increasing that is to say that change in brain electrical activity is inducing the change in heart electrical activity. Shifting of the power of both signal towards lower time period (or, higher frequency) is giving two-foldindication, firstly, EEG signal is affecting ECG signal and secondly, participation of signal of lower time period is increasing in comparison to normal time series of EEG and ECG.

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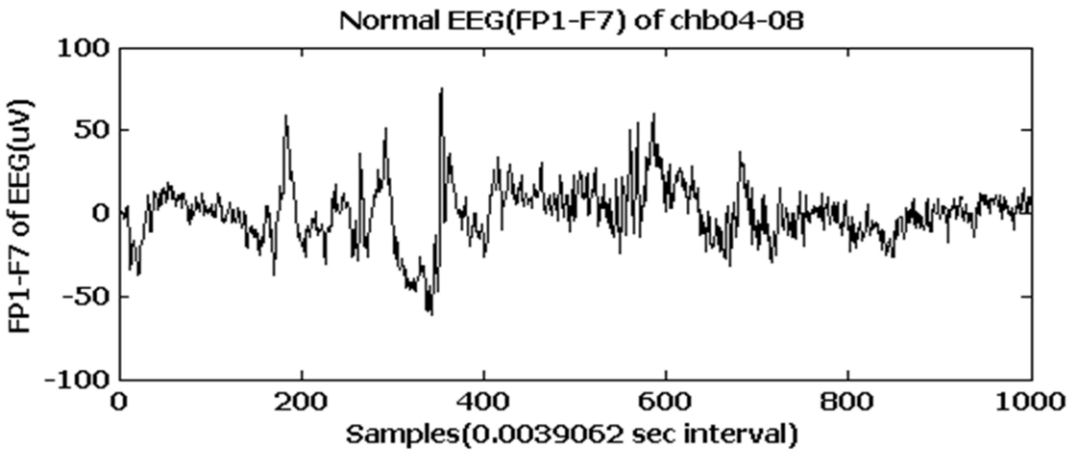

Fig. 1 (a) Wave form of chb04_08 files for normal EEG (FP1-F7 signal)

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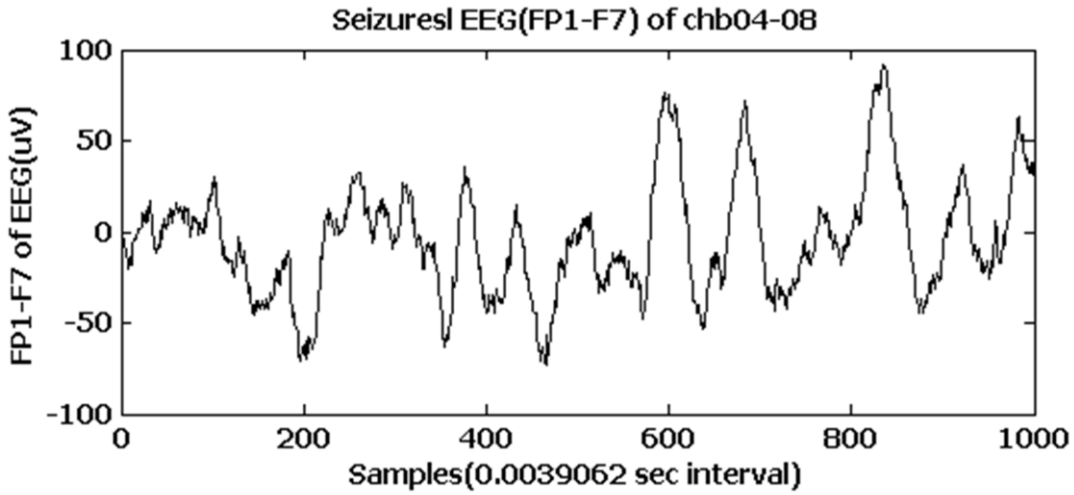

Fig. 1 (b) Wave form of chb04_08 files for seizures EEG (FP1-F7) signal

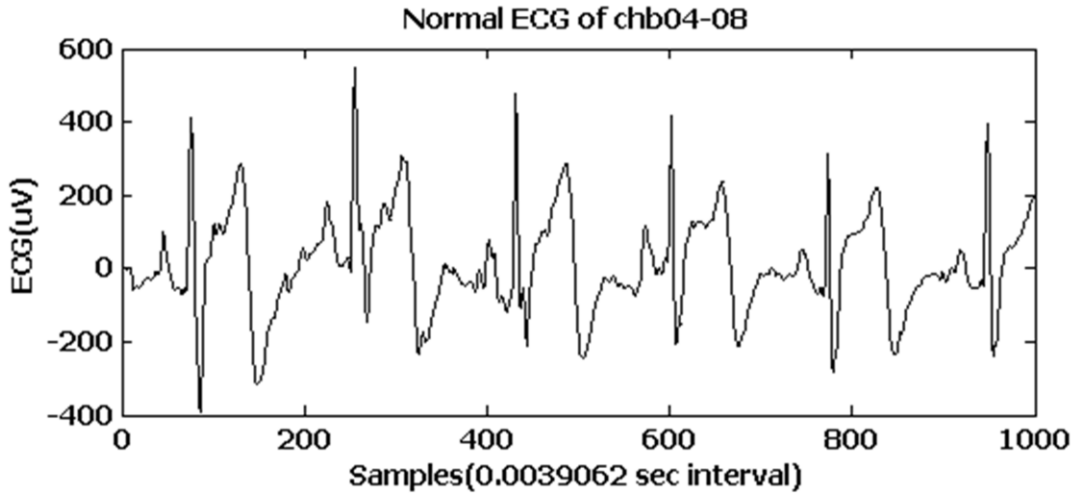

Fig. 1 (a) Wave form of chb04_08 files for normal ECG

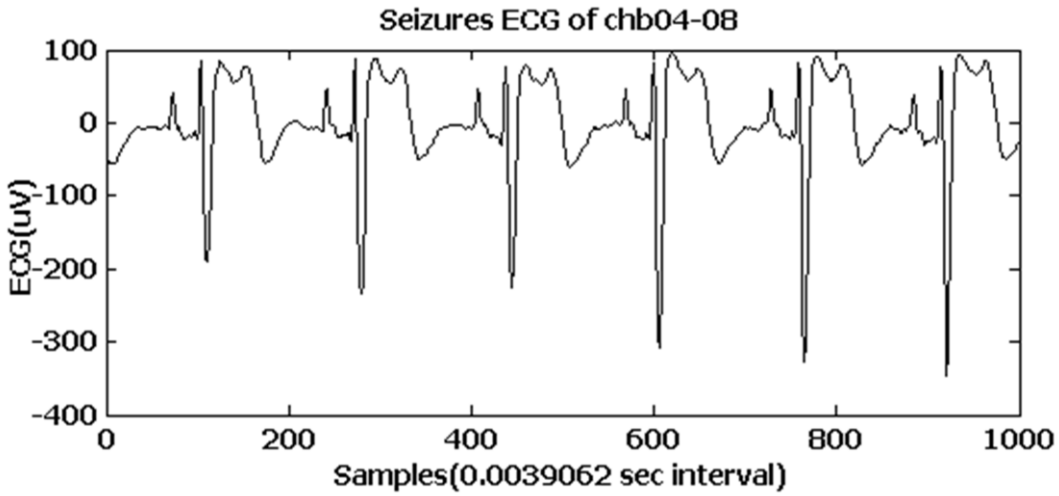

Fig. 2 (b) Wave form of chb04_08 files for seizures ECG

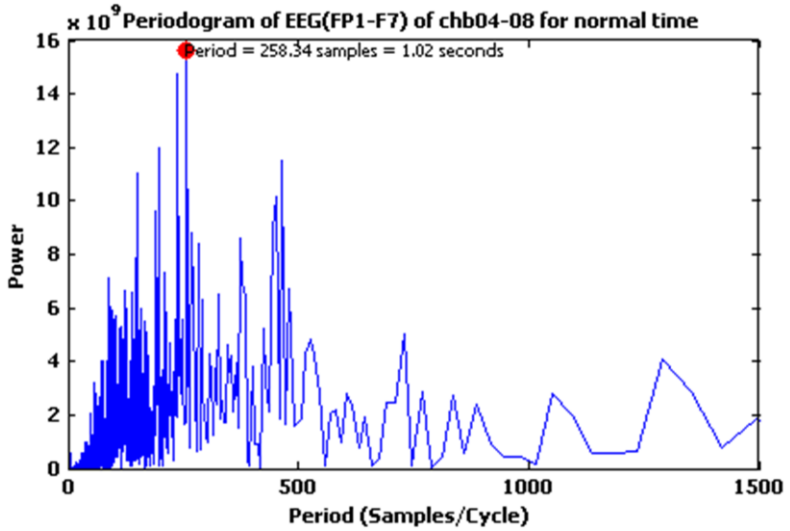

Fig. 3 (a): Fourier Power spectrum of chb04_08 files for normal EEG (FP1-F7)

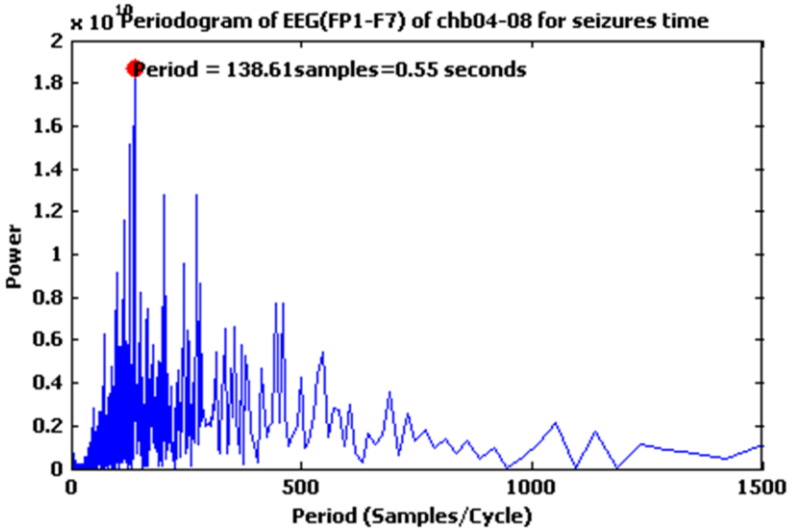

Fig. 3 (b): Fourier Power spectrum of chb04_08 files for seizures EEG (FP1-F7)

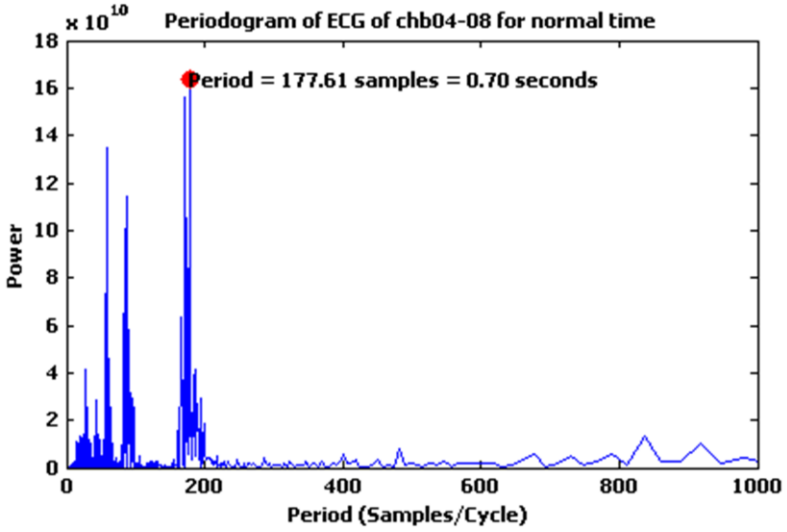

Fig. 4 (a): Fourier Power spectrum of chb04_08 files for normal ECG

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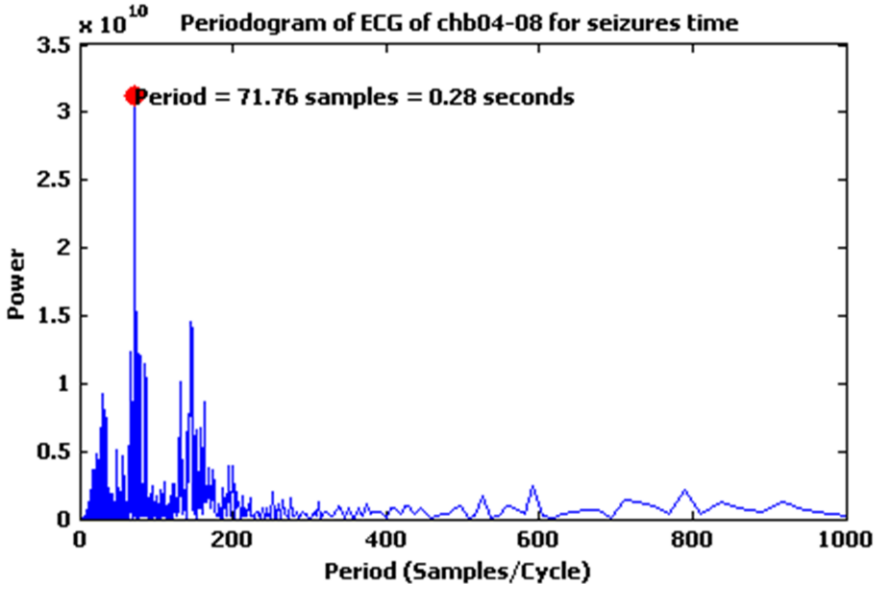


Fig. 4 (b): Fourier Power spectrum of chb04_08 files for seizures ECG

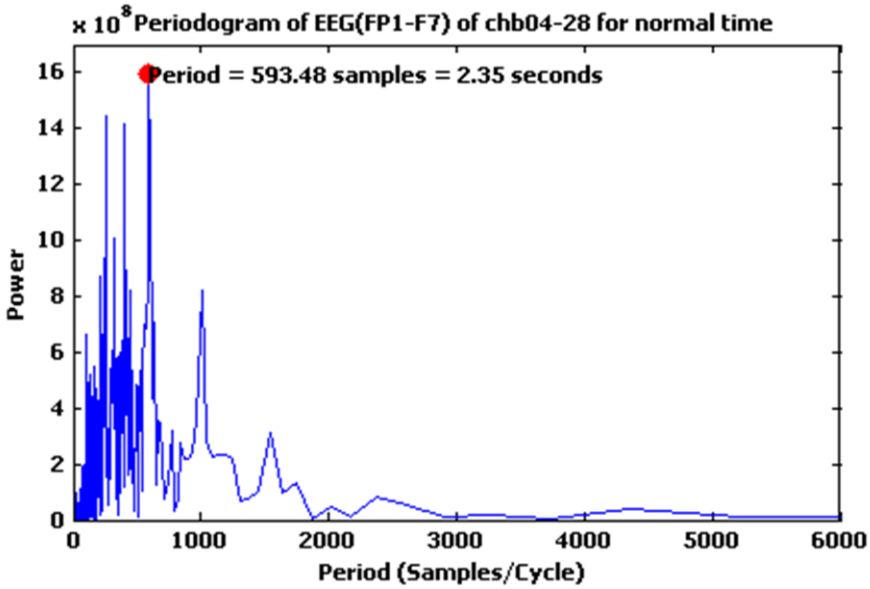
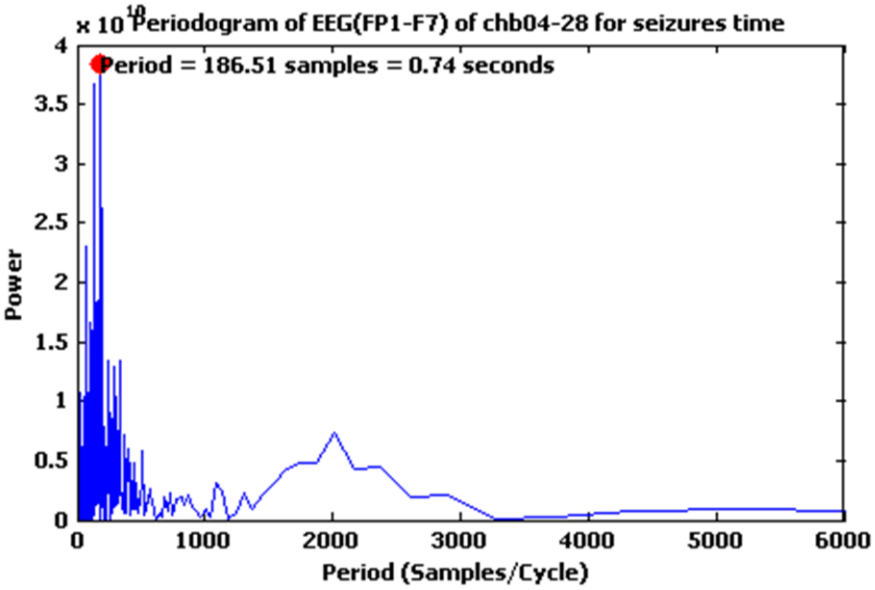


Fig. 5 (a): Fourier Power spectrum of chb04_28 files for normal EEG (FP1-F7)



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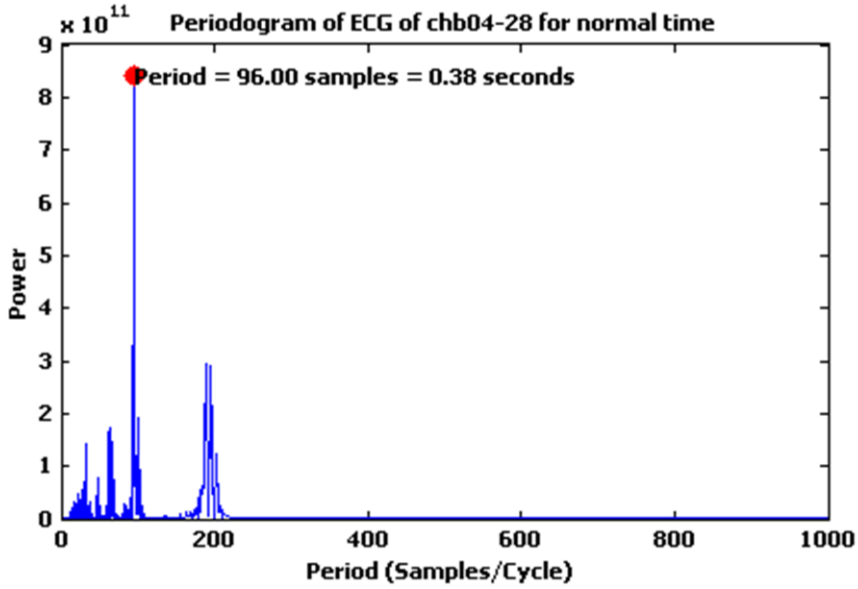

Fig. 6 (a): Fourier Power spectrum of chb04_28 files for normal ECG

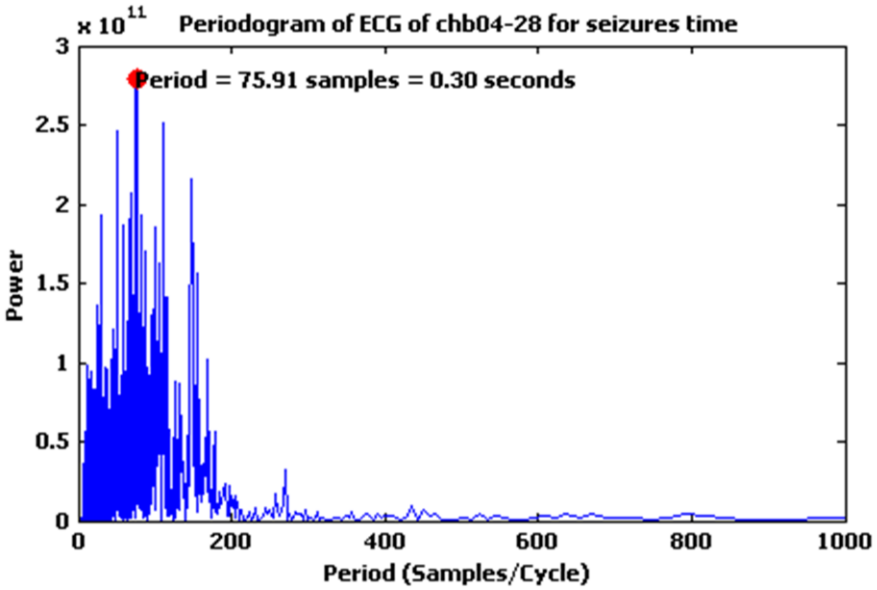

Fig. 6 (b): Fourier Power spectrum of chb04_28 files for seizures ECG

Table 1: Description of chb04_08.edf and chb04_28.edf record files

File Name	Start Time	End Time	No of Seizures	Seizures Start Time (sec)	Seizures End Time (sec)
chb04_08.edf	18:53:30	22:53:30	1	6446	6557
chb04_28.edf	00:04:47	4:05:10	2	1679	1781
				3782	3898

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Table 2: Central tendency and covariance of EEG and ECG of normal and seizures time of chb04_08.edf and chb04_28.edf record files

RefNo	Signal Types	Mean EEG	EEG Variance	Mean ECG	ECG Variance	EEG-ECG Covariance
chb04_08	Normal ECG and Normal EEG	-0.10	2842.62	0.22	21007.78	-89.75
	Seizer time ECG and Seizer time EEG	0.35	3152.68	-0.95	5556.38	-21.32
chb04_28	Normal ECG and Normal EEG	0.00	295.32	-0.18	63076.35	-167.76
	Seizer time ECG and Seizer time EEG	0.03	30358.66	0.26	198542.90	2064.90

Table 3: Period of Maximum Power of EEG (FP1-F7) and ECG of normal and seizures time of chb04_08.edf and chb04_28.edf record files

RefNo	Signal Types	Period of EEG (FP1-F7) signal of Maximum Power (seconds)	Period of ECG signal of Maximum Power (seconds)
chb04_08	Normal ECG and Normal EEG	1.02	0.70
	Seizer time ECG and Seizer time EEG	0.55	0.28
chb04_28	Normal ECG and Normal EEG	2.35	0.38
	Seizer time ECG and Seizer time EEG	0.74	0.30